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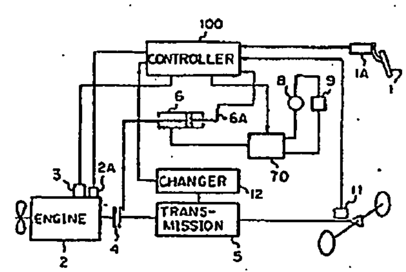
(54) **Automatic clutch control system.**

(57) An automatic clutch control system, for use in automobiles, using a microcomputer, including an accelerator pedal sensor for detecting accelerator position; an engine speed sensor for detecting engine speed; a clutch stroke sensor for detecting clutch stroke; an automobile speed sensor for detecting automobile speed; and a controller for controlling opening or closing of solenoid valves, gear change of a transmission, and opening or closing of a throttle actuator in accordance with predetermined stored data and signals transmitted from the sensors.

The automatic clutch control system consequently can automatically control the clutch moving time and clutch moving speed for easy driving under all driving conditions.

Moreover, while the clutch control system is automatic, it can use dry-type single-plate clutches and sliding-mesh-type transmissions as employed in manual and semiautomatic transmissions.

Fig. 4



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AUTOMATIC CLUTCH CONTROL SYSTEM

The present invention relates to a clutch control system, more particularly to a method and apparatus for an automatic clutch control system using a microcomputer.

The present invention is advantageously used, for example, for automobiles having conventional dry-type single-plate clutches and sliding-mesh-type transmissions.

The automatic clutch control system according to the present invention can automatically control the clutch moving time, clutch moving speed, and gear changes under a predetermined control program stored in a microcomputer, thus allowing easy driving under all driving conditions.

As is well known, three main types of transmissions are now in use for clutch control and gear change in automobiles: manual transmissions, using dry-type single-plate clutches and sliding-mesh-type transmissions, which are manually operated by a clutch pedal and a gear change lever; semiautomatic transmissions, also using dry-type single-plate clutches and sliding-mesh-type transmissions, which have a gear change mechanism manually operated by a change lever and a clutch automatically controlled by a computer; and automatic transmissions, for example, using torque converters and planetary-gear-type auxiliary transmissions, which are automatically controlled by a computer controller.

As is also well known, each of these types of transmission has its own advantages and disadvantages. The main disadvantages of manual transmissions are troublesome operability, poor smoothness of change, and susceptibility of efficiency to driving characteristics of individual drivers. The main disadvantage of

semiautomatic transmissions is poor smoothness of change. Finally, the main disadvantages of automatic transmissions are poor gas mileage (fuel consumption), slow response time, and high cost.

Although technical improvements have been made alleviating the above disadvantages, these improvements are still not sufficient.

An embodiment of the present invention can provide an automatic clutch control system, for use in automobiles, using a microcomputer which avoids or mitigates the disadvantages of the prior art.

Embodiments of the present invention can also provide an automatic clutch control system enabling highly precise, automatic control of the clutch moving time and clutch moving speed under various driving conditions.

An embodiment of the present invention can also provide an automatic clutch control system enabling use of conventional dry-type single-plate clutches and sliding-mesh-type transmissions.

In accordance with the present invention, there is provided an apparatus for an automatic clutch control system, for use in a motor vehicle, including a microcomputer, comprising: first means mounted to an accelerator pedal for sensing accelerator position; second means mounted to an engine for sensing engine speed; third means mounted to a clutch actuator for sensing clutch stroke; fourth means mounted to a transmission for sensing vehicle speed; and fifth means for controlling opening or closing of solenoid valves, gear change of a transmission, and opening or closing of a throttle actuator, based on predetermined stored data and based on signals transmitted from the first, second, third, and fourth sensing means, for automatic control of clutch moving time and clutch moving speed and easy driving under all driving conditions.

Moreover, there is provided a method for automatic clutch

control, for a motor vehicle, using a microcomputer, comprising the steps of: detecting accelerator position by an accelerator pedal sensor, engine speed by an engine speed sensor, clutch stroke by a clutch stroke sensor, and vehicle speed by a vehicle speed sensor; comparing the sensor data with predetermined stored data and calculating clutch moving time and clutch moving speed based on predetermined data for various driving conditions; controlling opening or closing of solenoid valves based on signals generated from flip-flop circuits via counters activated by the calculation; and controlling the clutch moving time and clutch moving speed by means of a clutch actuator controlled by the solenoid valves.

The present invention enables easy driving under all driving conditions and good operability and gas mileage compared with conventional manual, semiautomatic, and fully automatic transmissions. Moreover, it can be used with dry-type single-plate clutches and sliding-mesh-type transmissions used in conventional manual and semiautomatic transmissions.

Reference is made, by way of example, to the accompanying drawings in which:-

Fig. 1 is a schematic block diagram of an automatic clutch control system in a conventional semiautomatic transmission;

Fig. 2 is a partial schematic view of a clutch actuator shown in Fig. 1;

Fig. 3 is a timing chart of drive current applied to a solenoid valve (A), the quantity of oil flow through one solenoid valve (B), and the quantity of oil flow through another solenoid valve (C);

Fig. 4 is a schematic block diagram of an automatic clutch control system according to an embodiment of the present invention;

Fig. 5 is a schematic block diagram of a hydraulic control circuit including solenoid valves controlled by the controller shown in Fig. 4;

Fig. 6 is a schematic block diagram for explaining the automatic clutch control system shown in Fig. 4;

Fig. 7 to Fig. 9 are graphs for explaining relations between clutch stroke and clutch moving time (Fig. 7) and between clutch stroke and clutch moving speed (Fig. 8 and Fig. 9);

Fig. 10 shows timing charts for opening and closing of valves and the quantity of fluid flow therethrough;

Fig. 11 is a basic block diagram of the controller shown in Fig. 4; and

Fig. 12 is a flow chart of a clutch control procedure performed in the controller shown in Fig. 11.

In general, rotation of an automobile engine shaft is transmitted to the shaft of a transmission mechanism by a dry-type single-plate clutch. To control the clutch engagement, a hydraulic control actuator is used. The hydraulic control actuator is constituted by a hydraulic cylinder used to engage and disengage the clutch and a plurality of solenoid valves used to control the motion of the hydraulic cylinder. Control of the hydraulic actuator, i.e., control of the solenoid valves, is effected mechanically in manual transmissions and electronically in semiautomatic transmissions.

Before describing embodiments of the present invention, an explanation will be given of a conventional clutch control system for a semiautomatic transmission using a dry-type single-plate clutch and hydraulic control actuator.

Referring to Fig. 1, reference numeral 1 is an accelerator pedal, 1A an accelerator pedal sensor, 2 an engine, 2A an engine speed sensor, 3 a throttle actuator, 4 a clutch, 5 a transmission, 6 a clutch actuator, 6A a clutch stroke sensor, 7 a solenoid valve group, 8 an oil pump, 9 an oil tank, 10 a control unit, and 11 an automobile speed sensor.

The control unit 10, constituted by a microcomputer, con-

trols the throttle actuator 3 and the solenoid valve group 7 in accordance with a signal transmitted from the accelerator pedal sensor 1A, a signal transmitted from the engine speed sensor 2A, a signal transmitted from the clutch stroke sensor 6A, and a signal transmitted from the automobile speed sensor 11. The control unit 10 also feeds back the stroke signal transmitted from the clutch stroke sensor 6A to control the opening of the solenoid valve group 7 for engagement, slip, or disengagement of the clutch based on the clutch moving speed, as defined by clutch engagement, clutch slip, clutch disengagement, change in engine (rotation speed of the engine shaft), automobile speed, and other driving conditions.

In other clutch control systems used for semiautomatic transmission, the system feeds back a stroke signal transmitted from a clutch stroke sensor, engine speed sensor, and automobile speed sensor to control the duty ratio (ratio of opened and closed time) of solenoid valves by a control unit so as to obtain both a clutch moving speed and clutch moving time defined by engine speed, automobile speed, and other driving conditions.

However, it is difficult to obtain the desired clutch moving speed and clutch moving time by controlling the opening or closing of the solenoid valves because it is necessary to finely control the duty ratio of the valves, which necessitates complex valve control.

The above problems will be explained in detail hereinafter with respect to Fig. 2 and Fig. 3. Referring to Fig. 2, as mentioned above, the hydraulic control actuator is constituted by a clutch actuator, i.e., an oil cylinder 6, and a plurality of solenoid valves (V_1 to V_3). A piston 6B equipped with a piston rod 6C is provided in the oil cylinder 6. The solenoid valve V_1 is provided for exhaust in a small diameter fluid passage, and the solenoid valve V_2 is provided for exhaust in a large diameter fluid passage. The solenoid valve V_3 is provided for supply.

Although only two exhaust solenoid valves V_1 and V_2 are shown in the drawing, generally a plurality of fluid passages having the same diameters are provided in the actuator and each fluid passage is controlled by a solenoid valve. In the case shown in the drawing, the solenoid valve V_2 is used for coarse control of the oil flow, and solenoid valve V_1 for fine control of the oil flow.

Referring to Fig. 3, when a drive current having a pulse waveform as shown in (A) is applied to the solenoid valves V_1 and V_2, the oil flow through the solenoid valve V_1 in the small diameter fluid passage is shown by (B), and the oil flow through the solenoid valve V_2 in the large diameter fluid passage is shown by (C).

The oil flows through the solenoid valves V_1 and V_2 are constant so long as the pulse waveform of the drive current remains the same, i.e., has the same pulse width. The oil flow, however, changes when the pulse width becomes smaller or with increasingly smaller diameters of fluid passages, in order to achieve finer control, whereby the control of the hydraulic actuator becomes unstable (imprecise). Accordingly, it is difficult to obtain precise control of opening or closing of solenoid valves so as to obtain the desired clutch moving speed and clutch moving time.

An embodiment of an automatic clutch control system according to the present invention will now be explained in detail. As explained above, an automatic clutch control system according to the present invention can be used with conventional dry-type single-plate clutches and sliding-mesh-type transmissions. In embodiments of the present invention, the (gear) change lever used in semiautomatic transmissions is eliminated and a transmission changer (drive mechanism) added instead. These clutch and drive mechanisms are controlled by a microcomputer controller. Accordingly, a clutch control system according to the present invention is a fully automatic

transmission using a conventional clutch and transmission.

Referring to Fig. 4, the automatic clutch control system is constituted by the same components as shown in Fig. 1, except for a controller 100, a solenoid valve group 70, and a (gear) changer 12. Components the same as in Fig. 1 are indicated by the same reference numerals.

Referring to Fig. 5, the clutch 4 is constituted by a clutch pressure plate 4A, clutch disk 4B, diaphragm spring 4C, clutch release bearing 4D, clutch release lever 4E, clutch shaft 4F, and lever 4G. Reference numeral 2B is an engine flywheel; 701, 701', 702, and 703 solenoid valves in the solenoid group 70; B a battery; SW a power switch associated with an ignition switch; and AC an accumulator.

The clutch 4 is controlled by controlling the opening or closing of the solenoid valves 701, 701', 702, and 703 using the controller 100. The controller 100 consists of a microcomputer which has a stored program relating to driving conditions. When the solenoid valves 701 and 701', for example, are actuated by the controller 100, pressurized fluid is supplied to the oil cylinder 6 from the oil pump 8. The piston 6B of the oil cylinder 6 is thus moved toward the right as indicated by the arrow to disengage the clutch disk 4B. When the solenoid valves 702 and 703 are actuated by the controller 100, the pressurized fluid is exhausted from the oil cylinder 6. The piston 6B thus moves in the reverse direction due to the action of a return spring (not shown) to re-engage the clutch disk 4B.

This control of clutch engagement and disengagement will be explained in more detail hereinafter with respect to Figs. 6, 7, 8, 9, and 10.

The controller 100 stores various parameters, for example, a to d shown in Figs. 7 to 9, defining relations between the clutch stroke and clutch moving time or between the clutch stroke and clutch moving speed under various driving conditions,

such as upward or downward slopes, flat roads, and stopping. The controller 100 uses these parameters a to d and the signal transmitted from the clutch stroke sensor 6A, for example, a potentiometer, to calculate the desirable clutch moving speed and clutch moving time corresponding to the clutch stroke S and controls the solenoid valve group 70 based on the results of its calculations.

The control modes will be explained in more detail with respect to Figs. 7 to 9. Referring to Fig. 7, the ordinate indicates the clutch stroke (S) and the abscissa indicates the clutch moving time (T). The lines I, II, and III indicate clutch engagement (clutch on), clutch slip (half clutch), and clutch disengagement (clutch off). In the example/ shown on the graph, the clutch moving time is controlled to/ (determined as) a predetermined gradually increasing value in clutch operation from line III to line II and controlled to one of a set of predetermined gradually increasing values corresponding to a selected one of the driving condition parameters a to d in clutch operation from line II to line I.

In Figs. 8 and 9, the ordinates indicate the clutch stroke (S) and the abscissæ indicate the clutch moving speed (V). In the control modes of both Figs. 8 and 9, the clutch moving speed is controlled to a constant value in the clutch operation from line III to line II. In Fig. 8, clutch moving speed is controlled to one of a set of predetermined gradually decreasing values corresponding to a selected one of the driving condition parameters a to d in the clutch operation from line II to line I. In Fig. 9, the clutch moving speed is controlled to one of a set of predetermined constant values in clutch operation from line II to near line I and to a predetermined constant value to line I.

Next, fine control of the solenoid valves 701, 701', 702, and 703 shown in Fig. 5 and Fig. 6 will be explained in reference

to Fig. 10 (A) to (D).

Referring to Fig. 10, as mentioned above, the open ("on") and close ("off") timings of each solenoid valve 701, 701', 702, and 703 are controlled by the controller 100. The "on" and "off" timings can be independently selected by the controller 100. Generally, there is a time delay between the "on" and "off" timings in different valves. As a result, the quantity of oil flow through the valves changes gradually at the leading edges and trailing edges of the waveforms shown in Fig. 10.

In the case of two valves, when both valves are turned on nearly simultaneously by drive currents i_1 and i_2 and are left on for a long time, the quantity of oil flow Q is indicated by the hatched area in Fig. 10 (A). When both valves are simultaneously on (open) for a short time, the quantity of oil flow Q is as shown in Fig. 10 (B). When the upstream valve is changed from "on" to "off" and the downstream valve is changed from "off" to "on," the quantity of oil flow is as shown in Fig. 10 (C).

As is obvious from the waveform shown in Fig. 10 (D), the overlapping of the "on" and "off" timing of the valves affects the quantity of oil flow.

The method for controlling the quantity of oil flow according to the present invention is particularly advantageous when the solenoid valves 701, 701', 702, and 703 are controlled as shown in Figs. 10 (C) and (D). In the embodiment shown, the solenoid valves 701 and 701' are provided in series in the supply side fluid passage, while the solenoid valves 702 and 703 are provided in parallel in the exhaust side fluid passage. In conventional systems using a single solenoid valve in the supply side, the solenoid valve has not been able to operate fast enough in accordance with a rapid succession of "on" and "off" instructions. As a result, conventionally, the quantity of oil flow through the valves during "on" and "off" timing has been unstable (imprecise).

However, according to the present invention, "on" and "off" control of valves can be independently performed by the controller 100. Consequently, it is possible to control the solenoid valves 701, 701', 702, and 703 to operate at exactly the right timings. A stable flow of oil is possible even with an extremely small overlap of time in "on" timing.

Consequently, since the quantity of oil flow through each valve can be finely controlled by the microcomputer, the clutch moving speed and the clutch moving time can be/controlled precisely to suit various driving conditions.

Referring to Fig. 11, the controller 100 is mainly constituted by analog-digital converters AD1 to AD4, an address modifier AMO, memories M1 to M4, a comparator and calculator CAL, counters CNT1 to CNT4, and flip-flop circuits FF1 to FF4. The address modifier AMO, comparator and calculator CAL, and counters CNT are incorporated in a central processing unit CPU.

An analog output signal from for example, the accelerator pedal sensor 1A is applied to the analog-digital converter AD1. An analog output detected by, for example, the clutch stroke sensor 6A is applied to the analog-digital converter AD2. The digital outputs from the analog-digital converters AD1 and AD2 are applied to the memories M1 and M2, respectively, via the address modifier AMO. The digital outputs designate addresses in the memories (tables) M1 and M2.

Data/corresponding to the analog signals is read out from the tables and supplied to the comparator and calculator CAL and appropriately processed. In the case of memory M1, the resultant data is applied to the counter CNT1 for presetting the counter CNT1. The counter CNT1 sequentially counts down from the present/(preset) number using a periodically input pulse T and resets the flip-flop circuit FF1 when reaching zero based on/(together with) another periodically input pulse G.

The output of the flip-flop circuit FF1 is applied to a base of a transistor TR1. When the transistor TR1 turns on, the

solenoid valve 701 is activated. Whilst the counter CNT1 has not reached zero, the pulses G act to set the flip-flop circuit FF1, which turns off the transistor TR1, so deactivating the solenoid valve 701. Therefore, the smaller the preset number, the longer the "on" time of the solenoid valve 701. If the gate value which controls output of the memory MI is stored in another table, for example, memory M2, the clutch moving speed and clutch moving time can be controlled as shown in Figs. 7 to 9.

Referring to Fig. 12, the signals from each sensor, i.e., the accelerator pedal sensor 1A, the engine speed sensor 2A, the clutch stroke sensor 6A, and the vehicle speed sensor 11, are first applied to the analog-digital converters at step 1. These analog signals are converted to digital signals at step 2. The digital signals transmitted from the analog-digital converters designate addresses in the tables at step 3. The stored data corresponding to the sensor signals is read out from the tables and applied to the comparator and calculator CAL at step 4. The comparator and calculator CAL compares the read out data with prestored data of driving conditions <u>a</u>, <u>b</u>, <u>c</u>, and <u>d</u> and calculates differentials for obtaining clutch moving time and clutch moving speed based on commands transmitted from the central processing unit CPU at steps 5 and 6. The resultant data is applied to the counters, which sequentially count down from preset numbers based on periodically input pulses at step 7. The flip-flop circuits are reset by other periodically input pulses when the counts become zero at step 8. The outputs of the flip-flop circuits are applied to the bases of the transistors and the transistors turn on. The solenoid valves are activated by the current flowing through the transistors at step 9. Consequently, the cylinder stroke is controlled by the "on" or "off" timing of each valve at step 10. Therefore, the clutch stroke can be

suitably controlled for all driving conditions.

CLAIMS

1. An apparatus for an automatic clutch control system, for use in a motor vehicle, including a microcomputer, comprising:

first means mounted to an accelerator pedal for sensing accelerator position;

second means mounted to an engine for sensing engine speed;

third means mounted to a clutch actuator for sensing clutch stroke;

fourth means mounted to a transmission for sensing vehicle speed; and

fifth means for controlling opening or closing of solenoid valves, gear change of a transmission, and opening or closing of a throttle actuator, based on predetermined stored data and based on signals transmitted from the first, second, third, and fourth sensing means, for automatic control of clutch moving time and clutch moving speed under all driving conditions.

2. An apparatus as claimed in claim 1, wherein said third means comprises a potentiometer.

3. An apparatus as claimed in claim 1 or 2 wherein said fifth means comprises a microcomputer.

4. A method for automatic clutch control, for a motor vehicle using a microcomputer, comprising the steps of:

detecting accelerator position by an accelerator pedal sensor, engine speed by an engine speed sensor, clutch stroke by a clutch stroke sensor, and vehicle speed by an vehicle speed sensor;

comparing the sensor data with predetermined stored data and calculating clutch moving time and clutch moving speed based on predetermined data for various driving conditions;

controlling opening or closing of solenoid valves based on signals generated from flip-flop circuits via counters activated by the calculation; and

controlling the clutch moving time and clutch moving speed by means of a clutch actuator controlled by the solenoid valves.

5. A method as claimed in claim 4, wherein each said solenoid valve is independently controlled by said microcomputer.

6. A method as claimed in claim 4, or 5, wherein two of said solenoid valves are provided in series, a quantity of fluid flow being controlled by overlapping timing of opening or closing of said solenoid valves using said microcomputer.

7. A method as claimed in claim 4, 5 or 6, wherein said clutch moving time is controlled to a predetermined value from clutch disengagement to clutch slip and controlled to one of a set of predetermined values appropriate to driving conditions from clutch slip to clutch engagement.

8. A method as claimed in claim 4, 5, 6 or 7, wherein said clutch moving speed is controlled to a constant value from clutch disengagement to clutch slip and controlled to one of a set of predetermined values appropriate to driving conditions from clutch slip to clutch engagement.

9. A method as claimed in any of claims 4 to 8, wherein said clutch moving speed is controlled to one of a set of predetermined constant values appropriate to driving conditions from clutch slip to near clutch engagement and then to a predetermined constant value to clutch engagement.

10. A method as claimed in claim 6, wherein two of said solenoid valves are provided in series in a supply side fluid passage and another two of said solenoid valves are provided in parallel in an exhaust side fluid passage, a quantity of fluid

flow being controlled by overlapping periods of opening of said solenoid valves of both the supply and exhaust sides using said microcomputer.

11. A method as claimed in claim 10, wherein said exhaust side fluid passage has a different diameter from said supply side fluid passage.

Fig. 1

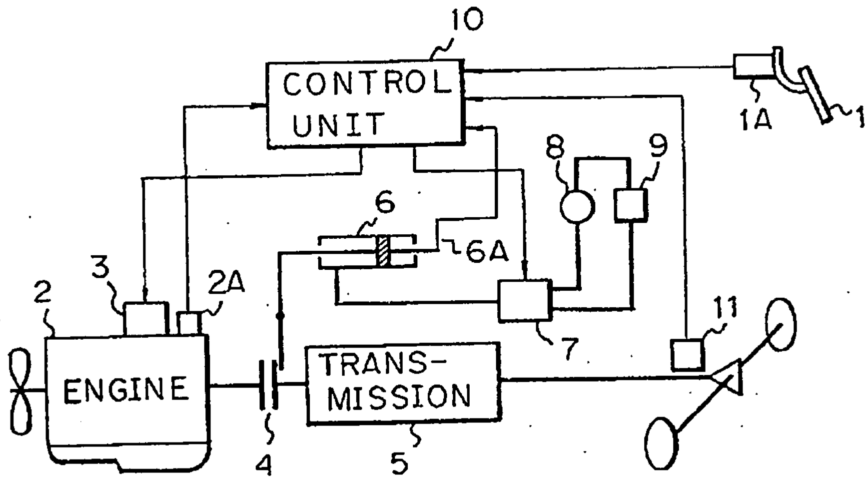

10
CONTROL UNIT
1A
1
8
9
6
6A
3
2A
2
7
11
ENGINE
TRANS-MISSION
4
5

Fig. 2

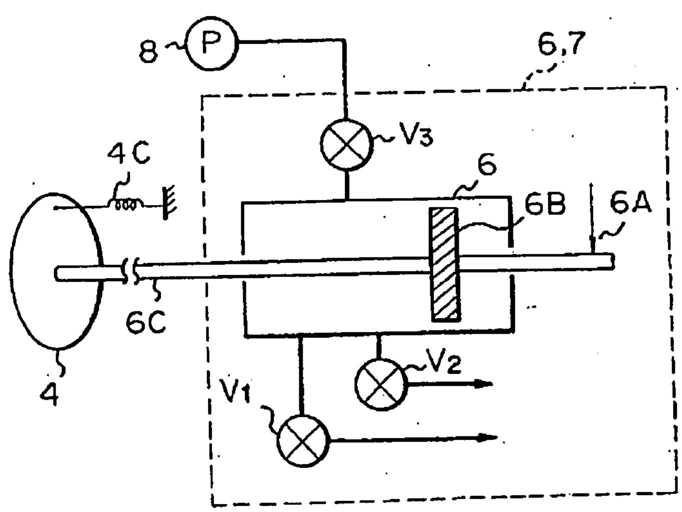

8
P
6,7
V3
4C
6
6B
6A
6C
4
V2
V1

Fig. 3

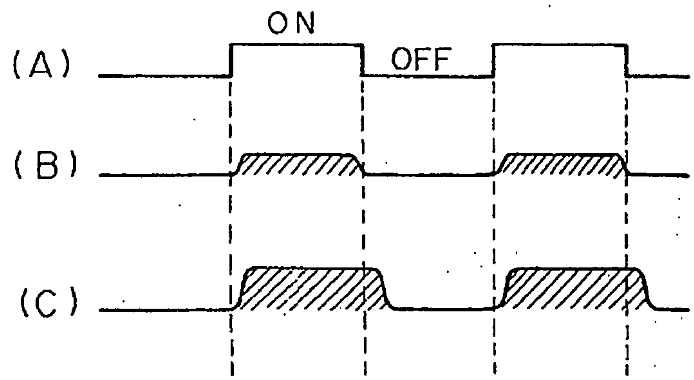

ON
OFF
(A)
(B)
(C)

Fig. 4

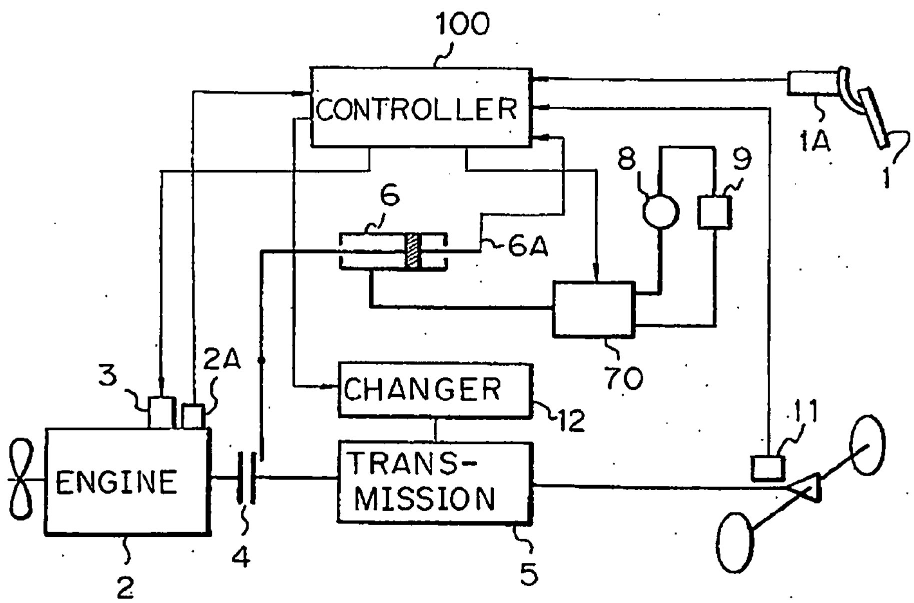

100
CONTROLLER
1A
1
8
9
6
6A
70
3
2A
CHANGER
12
11
ENGINE
TRANS-
MISSION
2
4
5

Fig. 5

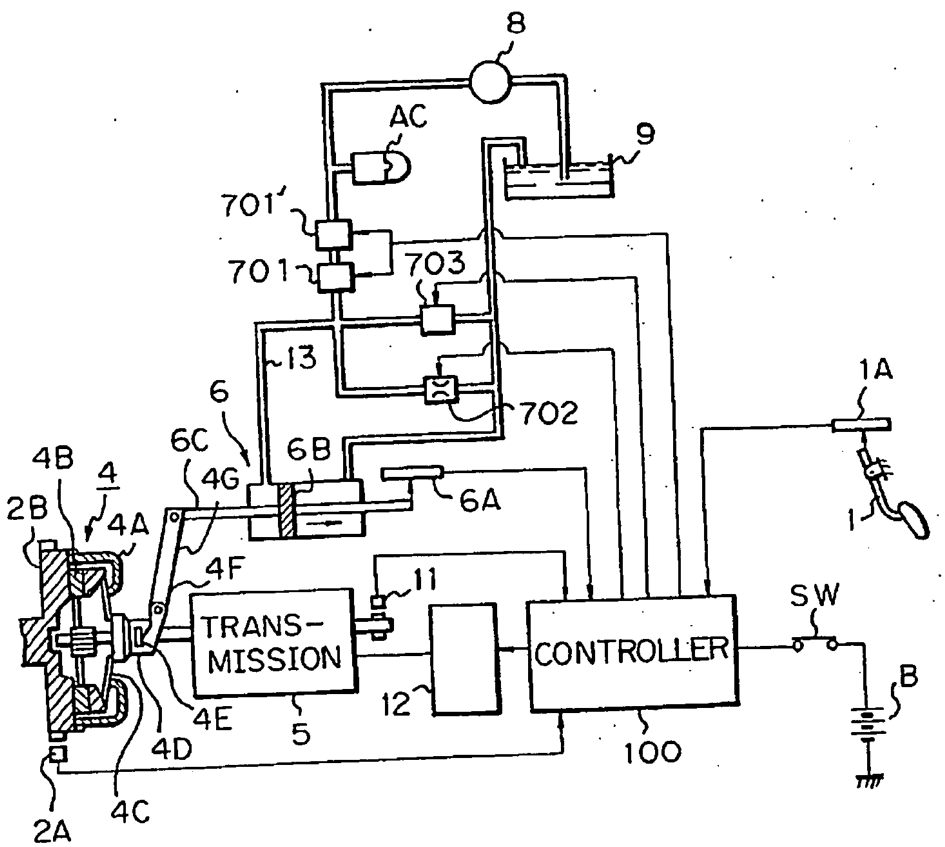

8
AC
9
701'
701
703
13
702
6
6C
6B
4G
6A
1A
1
4B
4
2B
4A
4F
11
TRANS-
MISSION
CONTROLLER
SW
B
12
4E
5
100
4D
2A
4C

Fig. 6

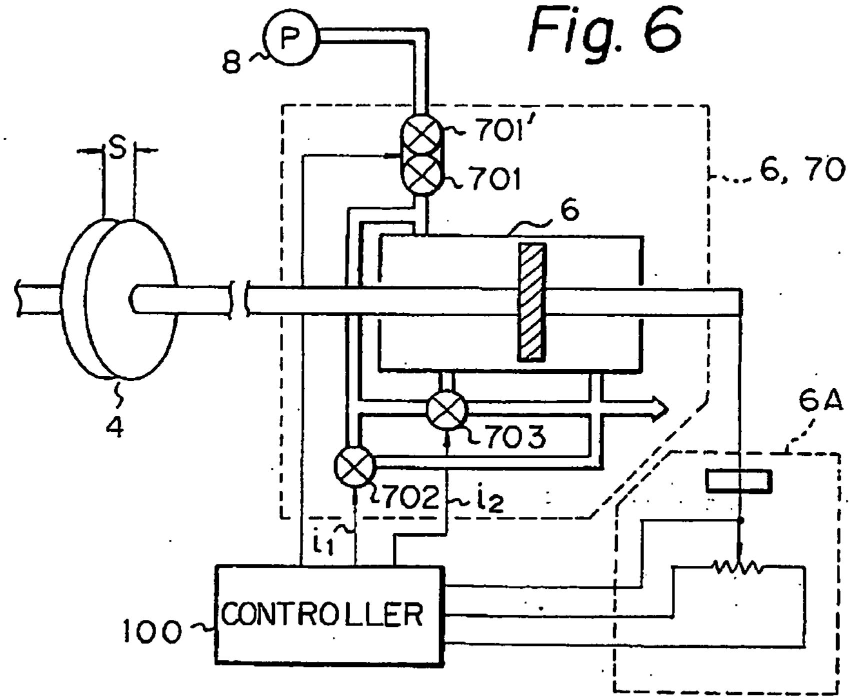

P
8
S
701'
701
6, 70
6
4
6A
703
702
i_2
i_1
CONTROLLER
100

Fig. 7

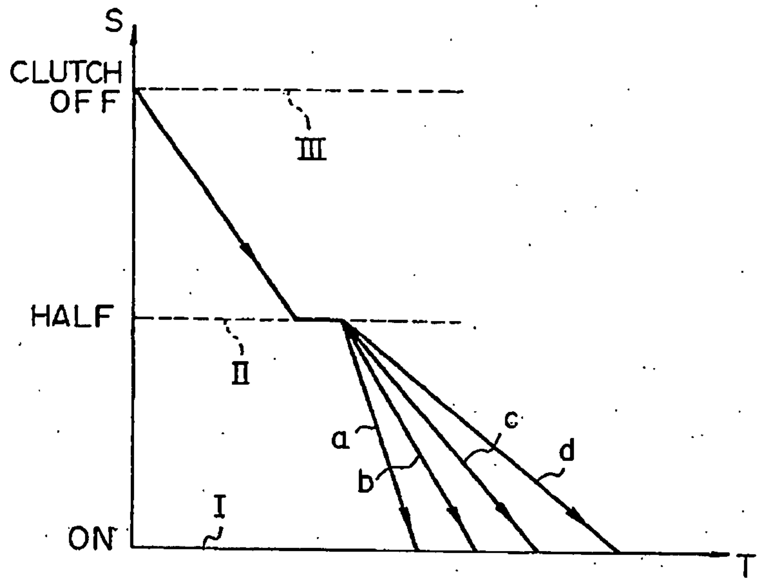

S
CLUTCH
OFF
III
HALF
II
a
b
c
d
I
ON
T

Fig. 8

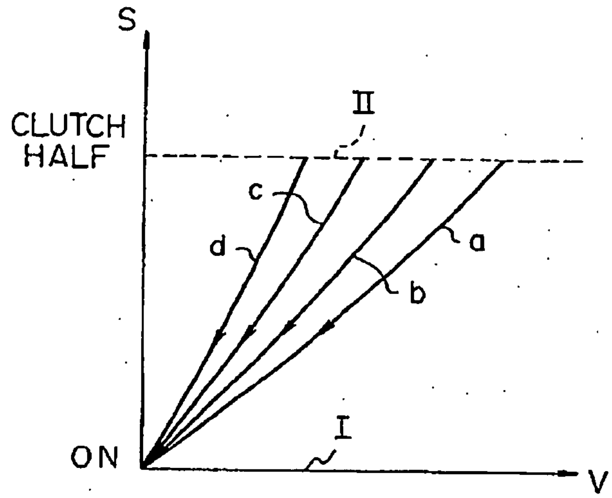


Fig. 9

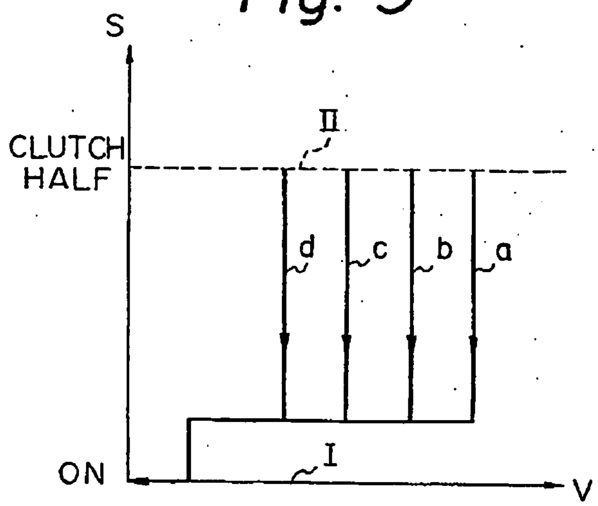


Fig. 10

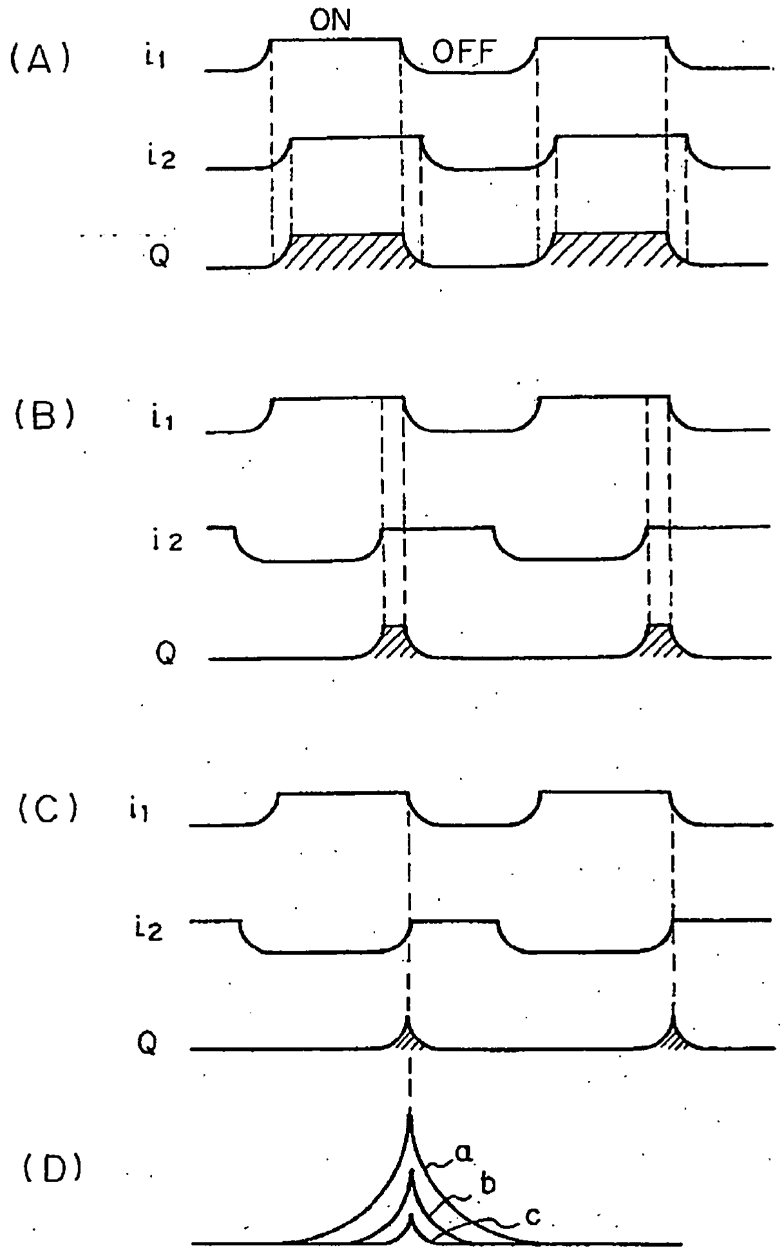


Fig. 11

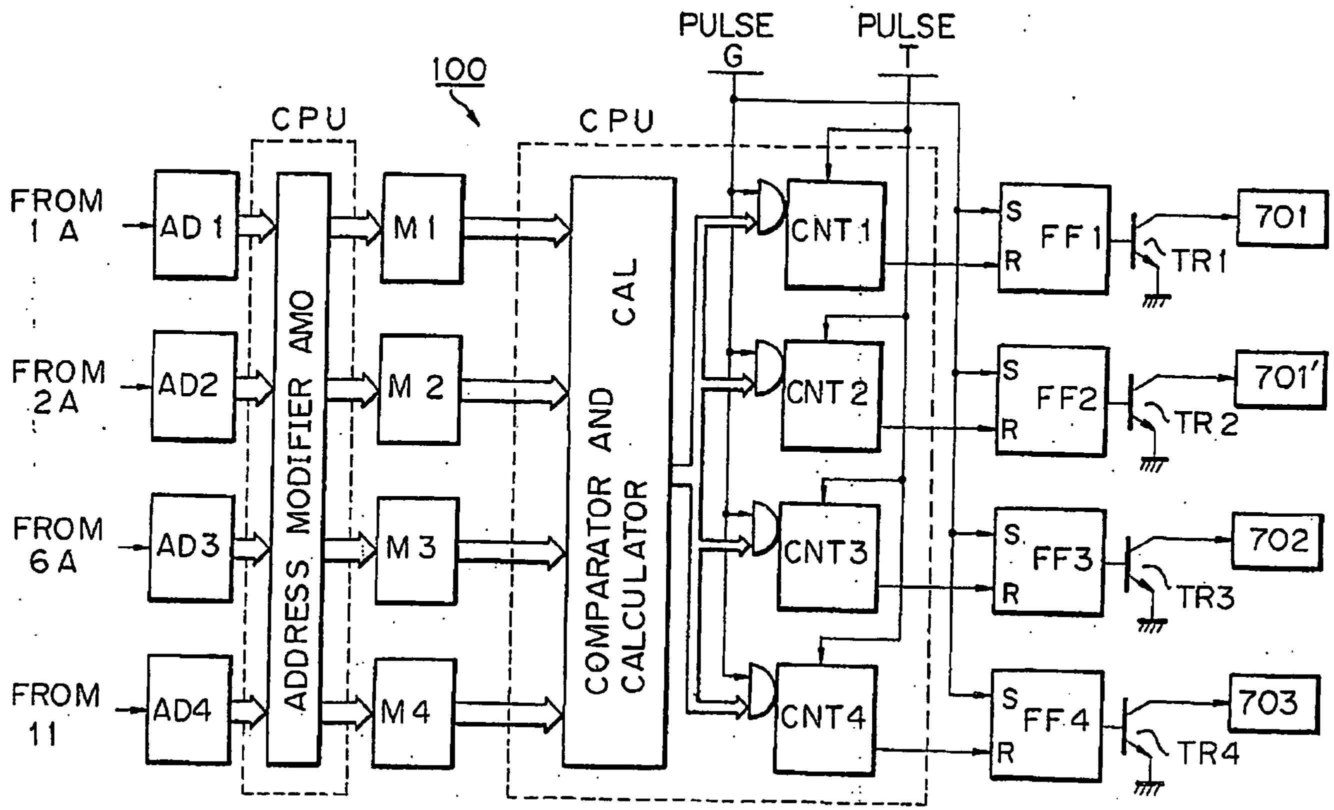
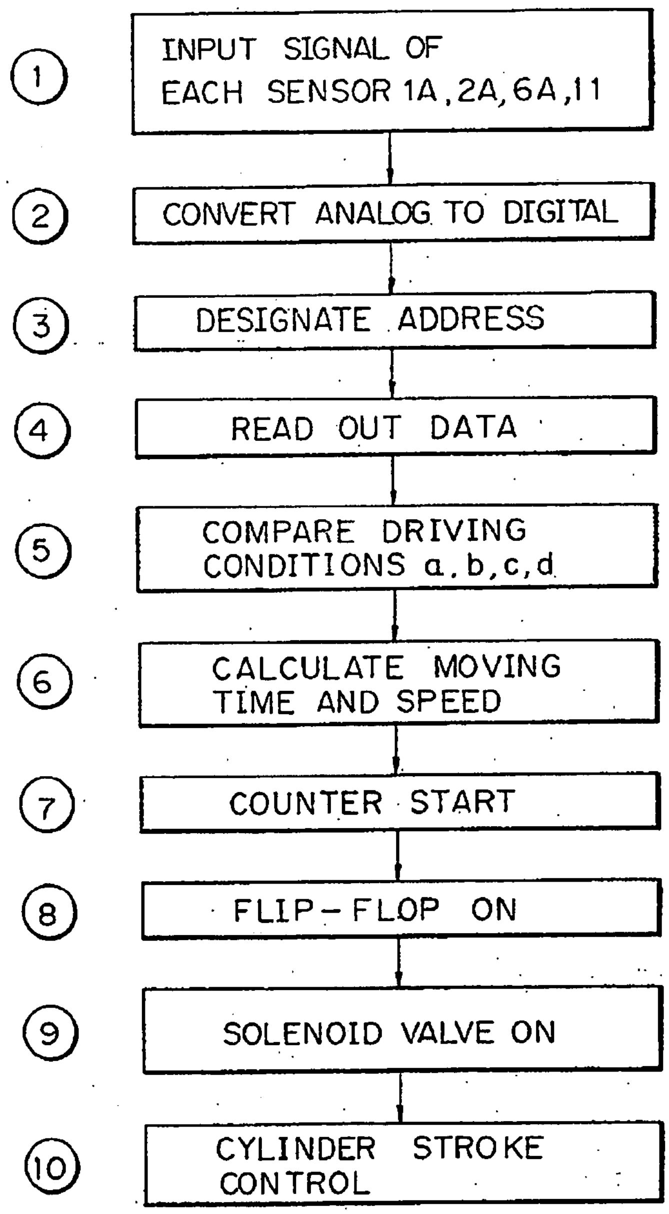

FROM 1 A
FROM 2A
FROM 6A
FROM 11
AD1
AD2
AD3
AD4
CPU
ADDRESS MODIFIER AMO
100
M1
M2
M3
M4
CPU
COMPARATOR AND CALCULATOR
CAL
PULSE G
PULSE T
CNT1
CNT2
CNT3
CNT4
S
R
FF1
FF2
FF3
FF4
TR1
TR2
TR3
TR4
701
701'
702
703

Fig. 12


1
INPUT SIGNAL OF EACH SENSOR 1A, 2A, 6A, 11
2
CONVERT ANALOG TO DIGITAL
3
DESIGNATE ADDRESS
4
READ OUT DATA
5
COMPARE DRIVING CONDITIONS a, b, c, d
6
CALCULATE MOVING TIME AND SPEED
7
COUNTER START
8
FLIP-FLOP ON
9
SOLENOID VALVE ON
10
CYLINDER STROKE CONTROL